Doc Code: PPH.PET.652

Document Description: Petition to make special under Patent Pros Hwy

PTO/SB/20IL (02-11)
Approved for use through 01/31/2012. OMB 0651-0058
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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REQUEST FOR PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM BETWEEN THE ISRAELI PATENT OFFICE AND THE USPTO

Application No.:	10/597,561	Filing Date:	2008-07-14
First Named Inventor:	Karni Volovelsky		
Attorney Docket No.:	26/832		

Title of the Invention: SUPER RESOLUTION IMAGE PROCESSING

THIS REQUEST FOR PARTICIPATION IN THE PPH pilot PROGRAM ALONG WITH THE REQUIRED DOCUMENTS MUST BE SUBMITTED VIA EFS-WEB. INFORMATION REGARDING EFS-WEB IS AVAILABLE AT HTTP://WWW.USPTO.GOV/EBC/EFS_HELP.HTML.

APPLICANT HEREBY REQUESTS PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM AND PETITIONS TO MAKE THE ABOVE-IDENTIFIED APPLICATION SPECIAL UNDER THE PPH PILOT PROGRAM.

The above-identified application (1) validly claims priority under 35 U.S.C. 119(a) and 37 CFR 1.55 to one or more corresponding IL application(s) or to a PCT application that does not contain any priority claim, or (2) is a national stage entry of a PCT application that does not contain any priority claim.

The IL/PCT application number(s) is/are: PCTIL05/000116
IL 160152

The filing date of the IL/ PCT application(s) is/are: PCT filing date- February 1,2005
IL filing date- February 1, 2004

I. List of Required Documents:

a. **A copy of all IL office actions which are relevant to patentability in the above-identified IL application(s)**

☑ Is attached.

b. **A copy of all claims which were determined to be patentable by the IL in the above-identified IL application(s)**

☑ Is attached.

c. **English translations of the documents in a. and b. above along with a statement that the English translations are accurate are attached (if the documents are not in the English language).**

d. **(1) An information disclosure statement listing the documents cited in the IL office actions**

☐ Is attached.

☑ Has already been filed in the above-identified U.S. application on 10/31/2010

(2) Copies of all documents (except for U.S. patents or U.S. patent application publications)

☐ Are attached.

☑ Have already been filed in the above-identified U.S. application on 10/31/2010

PTO/SB/20IL (02-11)
Approved for use through 01/31/2012. OMB 0651-0058
U.S.Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

REQUEST FOR PARTICIPATION IN THE PATENT PROSECUTION HIGHWAY (PPH) PILOT PROGRAM BETWEEN THE ISRAELI PATENT OFFICE AND THE USPTO

(continued)

Application No.:	10597561
First Named Inventor:	Karni Volovelsky

II. Claims Correspondence Table:

Claims in US Application	Patentable Claims in IL Application	Explanation regarding the correspondence
7	1	identical
8	2	identical
9	3	identical
10	4	identical
11	5	identical
12	6	identical

III. All the claims in the US application sufficiently correspond to the patentable/allowable claims in the IL application.

Signature /MMF/	Date 12/30/2011
Name (Print/Typed) Mark M. Friedman	Registration Number 33883

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

office action dated
22/6/2008

לכבוד
ד"ר מרק פרידמן בע"מ
מגדל משה אביב, ק.54 , רח' זיבוטינסקי 7
רמת- גן 52520

0

א.ג.נ.,

פ.ק. 25

תאריך: י"ט סיון תשס"ח
22.06.2008

(d) 22 oct 08
מספרכם: 26/604

המדון: **<u>הודעה על ליקויים בבקשת פטנט מס' 160152</u>**
סימוכין: מכתבכם מיום 01/08/2007

בהתאם להוראות תקנה 41 לתקנות הפטנטים (נוהלי הלשכה סדרי דין, מסמכים ואגרות), התשכ"ח - 1968, הנני להודיעכם כי נמצאו בבקשה הליקויים המפורטים להלן.

עליכם להשיב על הודעה זו תוך ארבעה חודשים מתאריכה, אך הנכם רשאים לבקש את הארכת התקופה. עם בקשה כאמור, שתוגש לפני תום התקופה, יש לשלם אגרה בסך 56 ש"ח בעד כל חודש או חלק ממנו.

ואלה הליקויים:

1. מערכת התביעות כוללת מספר רב מדי של תביעות בלתי תלויות לשיטה (4), בניגוד למקובל בלשכה. ראו החלטת הרשם אודות התנגדות לבקשת פטנט מס' 112858 מיום 29 בנובמבר 2004, סעיפים 38-35. וראו בנוסף, תקנה 20(א)(3).
לכאורה מורה מערכת התביעות על אמצאות שונות, בניגוד לסעיף 8 לחוק.
2. על אף האמור לעיל, על-מנת לייעל את הטיפול בבקשה, בוצע חיפוש מקדמי.
תביעה 1 לפחות נעדרת התקדמות המצאתית כנדרש לפי סעיף 5, לאור הפרסום:
REICHENBACH, Stephen E. and LI, Jing: "Restoration and Reconstruction from Overlapping Images for Multi-Image Fusion", IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 39, NO. 4, APRIL 2001, pp. 769-780
(הזמין בקישורית: http://cse.unl.edu/~reich/publications/tgsrs39-4.pdf)
המתאר שיטה לשחזור סצינה מתוך ריבוי דגימות, הכוללת מיצוע משוקלל של ערכים בהתאם למיקום המרחבי ביחס לפלט (ראו עמ' 778 עמודה ימנית שורה 26 ועד עמ' 779 עמודה שמאלית שורה 2 וכן שרטוט 12). שילוב גישה זו במסגרת תהליך סופר רזולוציה (המהווה מקרה פרטי של שחזור כנ"ל) כמות שתואר בפרסומי הידע הקודם הנזכרים במבוא לפירוט, ייראה מובן מאליו לבעל מקצוע בתחום.
השגה דומה תקפה, בשינויים המתחייבים לפי העניין, כלפי תביעה 18 אשר מתייחסת לשילוב דומה.

weighted average of values corresponds to smooth

3. נא לעדכננו לגבי ציטוטים נוספים לפי סעיף 18 לחוק.

בכבוד רב,
ערן רוס
עו"ד

לוט:
☐ מקור הפירוט
☐ שרטוטים – גיליונות מס'
☐ דף(ים) מס'
☒ מסמכים אחרים: קטעי הפרסום הרלבנטים

רח' הסדנא 4, תלפיות, ירושלים 93420
טל': 972-2-5651666 פקס: 972-2-5651641

office action dated 6/22/2008

Israeli Patent Office

22 June 2008

Notification of deficiencies in Israeli application 160152

In correspondence with rule 41 of the Patent Rules, we hereby inform you that deficiencies have been found in the above-mentioned application.

A response must be submitted within 4 months, extensions of time requested before the 4 months' deadline at the cost of 56 NIS per month.

1. The set of claims includes too many independent claims for method (4), in contradiction to what is customaty, see Registrar decision in opposition 112858 dated November 29 2004, clauses 35-38 (and also see rule 20 (a) (3)).Allegedly they refer to distinct inventions in contradiction to clause 8 of the Law.
2. In order to save time, a preliminary search has been carried out. Claim 1 and 8 lack inventive step, as required by clause 5 of the Patent Law, in light of the following publication: REICHENBACH "Restoration and Reconstructions from Overlapping Images for Multi-Image Fusion" IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING< VOL 39, NO 4 April 2001, pp 769-780 , which describes a method for reconstructing a scene from multiple samples, which includes a weighted average of values corresponding to the spatial location in relation to the output (see page 778, right column, line 26 until page 779 left column, line 2 and figure 12). Combining this approach with the process of super resolution (which is a particular example of such reconstruction) is described in the prior art publications mentioned in the summary, and are obvious to a person skilled in the art.
   The same applies, with the relevant changes, to claim 18, which refers to a similar combination.

3. Please submit an update of prior art references cited in corresponding applications.

Respectfully,
Eran Ross
Examiner

IN THE ISRAEL PATENT OFFICE

26 May 2009
Our File: 26/604

Memorandum re: Super-Resolution Image Processing
Israel Application No.160152
Filed: 1 February 2004
By: **Rafael Advanced Defense Systems Ltd.**

Dear Sirs,

This is a response to the Examiner's letter of 22 June 2008, which is being filed on or before 28 May 2009 and for which **eight** months' extension fees have been paid.

Enclosed please find replacement pages 22-27 of the specification, in duplicate, containing claims 1-11 which replace pages 22-32, claims 1-25, as filed.

The Examiner has objected to the presentation of 4 independent method claims, citing the Patent Registrar's decision in the opposition to Israel Patent Application 112858.

In order to address this issue, the Applicant has chosen to cancel claims 1-6 and 18-25 from the application, without prejudice. The remaining claims 7-17 are unchanged, but have been renumbered as claims 1-11. The Applicant reserves the right to file a divisional application under Section 24(א) of the Israel Patent Law (1967).

The Examiner has provisionally raised a question under Section 8 of the Law as to whether the claims relate to more than one invention. In response, the Applicant respectfully submits that the independent claims originally presented relate to a number of closely interrelated aspects which are preferably used together in synergy.

Thus, for example, the distinguishing features of original independent claim 13 (now claim 7) also appear in dependent claim 10 (now claim 4) depending from original independent claim 7 (now claim 1), while the distinguishing features of original claim 7 also appear in original dependent claim 16 (now claim 10) depending from original claim 13 (now 7).

Given that the various features recited in the independent claims all relate to the same overall process, and recite closely interrelated features which are preferably used together in synergy, the Applicant respectfully submits that the claims should not be considered "different inventions" in the sense of Section 8 of the Israel Patent Law.

The Examiner has also cited a Reichenbach reference as relevant to original claims 1 and 18. The Applicant respectfully disagrees. However, this issue is no longer relevant in view of the cancellation of claims 1-6 and 18-25 from the application.

Finally, regarding the Examiner's request under Section 18, we have received an International Search Report in the parallel PCT application no. PCT/IL05/000116. A copy of the search report and an accompanying CD are being submitted as part of an updated Section 18 submission in parallel to this response.

In view of the accompanying amendments and remarks, the Applicant believes that all issues raised by the Examiner have been fully addressed. Positive consideration is respectfully solicited.

Respectfully submitted,

Dr. Mark M. Friedman
Advocate, Patent Attorney
Moshe Aviv Towers, 54th Floor
7 Jabotinski Street
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WHAT IS CLAIMED IS:

1. A method for iterative derivation of a master image from a plurality of sampled images of non-identical, at least partially overlapping, regions of a scene, the master image having an output resolution greater than a maximum resolution of the sampled images, the method comprising:

(a) for each sampled image, defining:

(i) a transformation operator **F** mapping positions within the master image to corresponding positions in the sampled image,

(ii) a distortion operator **H** simulating a distortion associated with an imaging sensor from which the sampled image was generated, and

(iii) a sampling operator **D** for reducing an image from the output resolution to the resolution of the sampled image;

(b) for each sampled image, applying said transformation operator, said distortion operator and said sampling operator to a current master image hypothesis so as to generate a predicted image, and calculating a difference image having pixel values corresponding to the difference in corresponding pixel values between the sampled image and the predicted image;

(c) performing back-projection of each of said difference images to generate a correction image for the current master image hypothesis; and

(d) employing said correction images to perform a correction to the current master image hypothesis to generate a new master image hypothesis,

wherein said back projection includes employing an operator $\mathbf{H}^{bp}$ corresponding to a pseudo-inverse of distortion operator **H**, wherein $\mathbf{H}^{bp}$ approximates to an inverse of **H** at spatial frequencies below a given value and approaches zero at spatial frequencies above said given value.

2. The method of claim 1, wherein $\mathbf{H}^{bp}$ is chosen to substantially satisfy the condition:

$$\mathbf{H}^{bp} \times \mathbf{D}^{t} \times \mathbf{D} \times \mathbf{H} = \mathbf{I}$$

wherein:

I is the unit operator for an image of the output resolution;

D is a sampling operator for reducing an image from the output resolution to the resolution of an input image; and

$\mathbf{D}^{t}$ is an inflation operator for expanding an image from the resolution of the input image to the output resolution.

3. The method of claim 1, wherein distortion operator **H** corresponds to a combination of a modulation transfer function resulting from an optical system of the imaging sensor and a modulation transfer function resulting from a distortion generated by a sensor element array of the imaging sensor.

4. The method of claim 1, wherein distortion operator **H** corresponds to a modulation transfer function describing only a first portion of a distortion generated by the imaging sensor, the method further comprising a post-processing step of deconvoluting a final master image hypothesis to substantially correct a modulation transfer function describing a remainder of a distortion generated by the imaging sensor.

5. The method of claim 1, wherein said correction to the current master image hypothesis includes combining the correction images by deriving a weighted average of values of corresponding pixels in said correction images, the weight of each pixel in each correction image being calculated as a function of a distance as measured in the sampled image between: (i) a point in the sampled image to which the pixel in the correction image is mapped by the transformation operator; and (ii) at least one pixel centroid proximal to said point.

6. The method of claim 5, wherein said function of a distance is derived from distortion operator **H**.

7. A method for iterative derivation of a master image from a plurality of sampled images of non-identical, at least partially overlapping, regions of a scene, the master image having an output resolution greater than a maximum resolution of the sampled images, the method comprising:

(a) for each sampled image, defining:

(i) a transformation operator **F** mapping positions within the master image to corresponding positions in the sampled image,

(ii) a distortion operator **H** simulating only a first portion of a distortion generated by an imaging sensor from which the sampled image was generated, and

(iii) a sampling operator **D** for reducing an image from the output resolution to the resolution of the sampled image;

(b) for each sampled image, applying said transformation operator, said distortion operator and said sampling operator to a current master image hypothesis so as to generate a predicted image, and calculating a difference image having pixel values corresponding to the difference in corresponding pixel values between the sampled image and the predicted image;

(c) performing back-projection of each of said difference images to generate a correction image for the current master image hypothesis;

(d) employing said correction images to perform a correction to the current master image hypothesis to generate a new master image hypothesis; and

(e) after performing steps (b) through (d) at least once, deconvoluting a final master image hypothesis to substantially

correct a remaining portion of a distortion generated by the imaging sensor from which the sampled image was generated.

8. The method of claim 7, wherein said correction to the current master image hypothesis includes combining the correction images by deriving a weighted average of values of corresponding pixels in said correction images, the weight of each pixel in each correction image being calculated as a function of a distance as measured in the sampled image between: (i) a point in the sampled image to which the pixel in the correction image is mapped by the transformation operator; and (ii) at least one pixel centroid proximal to said point.

9. The method of claim 8, wherein said function of a distance is derived from distortion operator **H**.

10. The method of claim 7, wherein said back projection includes employing an operator $\mathbf{H}^{bp}$ corresponding to a pseudo-inverse of distortion operator **H**, wherein $\mathbf{H}^{bp}$ approximates to an inverse of **H** at spatial frequencies below a given value and approaches zero at spatial frequencies above said given value.

11. The method of claim 7, wherein said back projection includes employing an operator $\mathbf{H}^{bp}$ corresponding to a pseudo-inverse of distortion operator $\mathbf{H}$, wherein $\mathbf{H}^{bp}$ is chosen to substantially satisfy the condition:

$$\mathbf{H}^{bp} \times \mathbf{D}^{t} \times \mathbf{D} \times \mathbf{H} = \mathbf{I}$$

wherein:

$\mathbf{I}$ is the unit operator for an image of the output resolution;

$\mathbf{D}$ is a sampling operator for reducing an image from the output resolution to the resolution of an input image; and

$\mathbf{D}^{t}$ is an inflation operator for expanding an image from the resolution of the input image to the output resolution.

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טלפון:
פקסימילה:

May 26, 2009

Our ref 26/604
IL application no. 160152
Applicant- RAFAEL – Advanced Defense Systems Ltd.
Title: "Super-Resolution Image Processing"

UPDATE OF REFERENCES

-PCT/IL05/000116: International Search Report is enclosed.

Additional applications were filed in: US, EP, CA, AU - no citations yet.

CD including full copies of references cited is enclosed.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL05/00116

A. CLASSIFICATION OF SUBJECT MATTER
IPC: G06K 9/32(2006.01)

USPC: 382/293-295,298-300,298-300
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 382/293-295,298-300

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6,456,339 B1 (SURATI et al.) 24 September 2002 (24.09.2002), column 6, lines 1-40, columns 14-17.	18-23
A	US 5,649,032 A (BURT et al.) 15 July 1997 (15.07.1997), column 2, lines 1-44.	1-25

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 September 2006 (20.09.2006)	12 SEP 2008
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (571) 273-3201	Authorized officer Bhavesh Mehta Telephone No. (703)305-3900

Form PCT/ISA/210 (second sheet) (April 2005)

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 August 2005 (11.08.2005)

PCT

(10) International Publication Number
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G06K 9/32 (2006.01)

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(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
160152 1 February 2004 (01.02.2004) IL

(71) Applicant *(for all designated States except US)*: **RAFAEL - ARMAMENT DEVELOPMENT AUTHORITY LTD.** [IL/IL]; P.O.Box 2250, 31021 Haifa (IL).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **VOLOVELSKY, Karni** [IL/IL] (IL). **GOLAN, Motti** [IL/IL] (IL). **GOLDGERG, Nitzan** [IL/IL] (IL).

(74) Agent: **FRIEDMAN, Mark**; 7 Jabotinsky St., 52520 Ramat Gan (IL).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

(88) Date of publication of the international search report:
2 April 2009

WO 2005/072060 A3

(54) Title: SUPER-RESOLUTION IMAGE PROCESSING

(57) Abstract: A method for iterative derivation of a master image from sampled images of non-identical, at least partially overlapping, regions of a scene. The method includes defining a transformation operator mapping positions within the master image to corresponding positions in the sampled image; a distortion operator simulating a modulation transfer function associated with an imaging sensor from which the sampled image was generated; and a sampling operator for reducing an image from the output resolution to the resolution of the sampled image. For each sampled image the transformation operator, distortion operator and sampling operator are applied to a current master image hypothesis to generate a predicted image A difference image is calculated which has pixel values corresponding to the difference in corresponding pixel values between the sampled image and the predicted image. A back-projection of each of the difference images is performed to generate a correction image for the current master image hypothesis. Finally, the correction images are employed to perform a correction to the current master image hypothesis to generate a new master image hypothesis. The correction to the current master image hypothesis includes combining the correction images by deriving a weighted average of values of corresponding pixels in the correction images. The weight of each pixel in each correction image is calculated as a function of a distance as measured in the sampled image between: a point in the sampled image to which the pixel in the correction image is mapped by the transformation operator; and at least one pixel centroid proximal to that point.

105

מדינת ישראל
משרד המשפטים

רשות הפטנטים

office action dated
8/25/2009

פ.ק. 25

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לכבוד
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א.ג.נ.,

הנדון: **<u>הודעה על ליקויים בבקשת פטנט מס' 160152</u>**
סימוכין: מכתבכם מיום 27/05/2009

לתשומת לבכם: מקום בו הנכם מופנים לחוק, הכוונה היא לחוק הפטנטים, התשכ"ז – 1967. מקום בו הנכם מופנים לתקנות, הכוונה היא לתקנות הפטנטים (נוהלי הלשכה, סדרי דין, מסמכים ואגרות), התשכ"ח – 1968. בהתאם להוראות תקנה 41 הנני להודיעכם כי נמצאו בבקשה הניל הליקויים המפורטים להלן.
עליכם להשיב על הודעה זו תוך ארבעה חודשים מתאריכה, אך הנכם רשאים לבקש את הארכת התקופה. עם בקשה כאמור שתוגש לפני תום התקופה יש לשלם אגרה בסך 59 ש"ח בעד כל חודש או חלק ממנו.

ואלה הליקויים:

1. התביעות הבלתי-תלויות 1 ו-7 (בגרסה 2) מורות על אמצאות שונות, בניגוד לסעיף 8 לחוק, כדלקמן:

אמצאה I: הפרדת-על עם הטלה-לאחור באמצעות אופרטור המקרב בתדרים הנמוכים פעולה הופכית לעיוות הנובע מחיישן הדימות וביתר התדרים יורד לאפס;

אמצאה II: הפרדת-על ללא שקלול לפחות חלק מהעיוות הנובע מחיישן הדימות לתוך חישוב חוזר-ונשנה, עם פיצוי על כך בצעד שלאחר-עיבוד.

לפיכך, לפי סעיף 24(ב) לחוק הנכם נדרשים בזאת לחלק את הבקשה. לתשומת לבכם, על פי תקנה 51 לתקנות הפטנטים וחוזר הרשם מ.נ. 62 יש להגיש את בקשות החלוקה או בקשה להארכת מועד להגשתן תוך ארבעה חודשים ממכתב זה.

בכבוד רב,
שרון פרי
בוחנת פטנטים

לוט:
☐ מקור הפירוט
☐ שרטוטים – גיליונות מס'
☐ דף(ים) מס'
☐ מסמכים אחרים:

Israeli Patent Office

25 August 2009

Notification of deficiencies in Israeli application 160152

In correspondence with rule 41 of the Patent Rules, we hereby inform you that deficiencies have been found in the above-mentioned application.

A response must be submitted within 4 months, extensions of time requested before the 4 months' deadline at the cost of 59 NIS per month.

1. **The independent claims 1 and 7 (version 2) are drawn to separate invention, contrary to clause 8 of the Patent law.**

Invention 1 - drawn to super division with backwards projection which approximate at low frequencies the opposite action of distortion which results from the imaging sensor and nears zero in remaining frequencies.

Invention 2- drawn to super division without averaging at least part of the distortion resulting from the imaging sensor into a repetitive calculation with a compensation that is received after the processing step.

Under Sec 24 (2) of the Law. You are required to divide the application. Please note that under rule 51 and Registrar Notice 62, the divisional applications should be filed within 4 months or request for extensions should be submitted..

Sharon Perry, Examiner

IN THE ISRAEL PATENT OFFICE

27 December 2009
Our File: 26/604

Memorandum re: Super-Resolution Image Processing
Israel Application No.160152
Filed: 1 February 2004
By: **Rafael Advanced Defense Systems Ltd.**

Dear Sirs,

This is a response to the Examiner's letter of 25 August 2009, which is being filed on or before 25 December and for which no extension fees are due.

As per the examiner's request, claims 7-11 are being cancelled from this application, and are being submitted in parallel as part of a divisional application.

Please find enclosed replacement pages 3-7 of the specification, in duplicate, which amend the summary to conform to the claims, as required by Hozer Rasham P 23.

Please also find enclosed replacement page 21, in duplicate, to which a sentence was added to ensure that the specification corresponds with the claims.

Finally, please also please find enclosed replacement page 24 which is now the last page of the claims and to which a signature has been added. Pages 25-26 have been deleted.

Respectfully submitted,

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partially overlapping, regions of a scene. The present invention also provides a technique, useful both alone and as part of the iterative derivation, for combining a plurality of input images into a single higher resolution output image.

According to the teachings of the present invention there is provided, a method for iterative derivation of a master image from a plurality of sampled images of non-identical, at least partially overlapping, regions of a scene, the master image having an output resolution greater than a maximum resolution of the sampled images, the method comprising: (a) for each sampled image, defining: (i) a transformation operator **F** mapping positions within the master image to corresponding positions in the sampled image, (ii) a distortion operator **H** simulating a modulation transfer function associated with an imaging sensor from which the sampled image was generated, and (iii) a sampling operator **D** for reducing an image from the output resolution to the resolution of the sampled image; (b) for each sampled image, applying the transformation operator, the distortion operator and the sampling operator to a current master image hypothesis so as to generate a predicted image, and calculating a difference image having pixel values corresponding to the difference in corresponding pixel values between the sampled image and the predicted image; (c) performing back-projection of each of the difference images to generate a correction image for the current master image hypothesis;

and (d) employing the correction images to perform a correction to the current master image hypothesis to generate a new master image hypothesis.

wherein said back projection includes employing an operator $\mathbf{H}^{bp}$ corresponding to a pseudo-inverse of distortion operator $\mathbf{H}$, wherein $\mathbf{H}^{bp}$ approximates to an inverse of $\mathbf{H}$ at spatial frequencies below a given value and approaches zero at spatial frequencies above said given value.

According to a further first aspect of the present invention, The method of claim **Error! Reference source not found.**, wherein $\mathbf{H}^{bp}$ is chosen to substantially satisfy the condition:

$$\mathbf{H}^{bp} \times \mathbf{D}^{t} \times \mathbf{D} \times \mathbf{H} = \mathbf{I}$$

wherein:

$\mathbf{I}$ is the unit operator for an image of the output resolution;

$\mathbf{D}$ is a sampling operator for reducing an image from the output resolution to the resolution of an input image; and

$\mathbf{D}^{t}$ is an inflation operator for expanding an image from the resolution of the input image .

According to a further aspect of the present invention wherein distortion operator **H** corresponds to a combination of a modulation transfer function resulting from an optical system of the imaging sensor and a modulation transfer function resulting from a distortion generated by a sensor element array of the imaging sensor.

According to a further aspect of the present invention, wherein distortion operator **H** corresponds to a modulation transfer function describing only a first portion of a distortion generated by the imaging sensor, the method further comprising a post-processing step of deconvoluting a final master image hypothesis to substantially correct a modulation transfer function describing a remainder of a distortion generated by the imaging sensor.

According to a further aspect of the present invention wherein said correction to the current master image hypothesis includes combining the correction images by deriving a weighted average of values of corresponding pixels in said correction images, the weight of each pixel in each correction image being calculated as a function of a distance as measured in the sampled image between: (i) a point in the sampled image to which the pixel in the correction

image is mapped by the transformation operator; and (ii) at least one pixel centroid proximal to said point.

According to a further aspect of the present invention, wherein said function of a distance is derived from distortion operator **H**.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a flow diagram of a method according to the teachings of the present invention for iterative derivation of a high-resolution master image from lower resolution sampled images;

FIG. 2 is a schematic illustration of the iterative process performed by the method of Figure 1;

FIGS. 3A and 3B are schematic representations of the sensor array of an imaging sensor and of an associated modulation (distortion) of imaging sensitivity, respectively;

from the optical system MTF. This deconvolution may be performed by any of a number of known deconvolution techniques. The deconvolution process of the post processing is thus rendered very much more efficient since it is performed only once on the final image rather than on each sampled image.

It will be appreciated that the above descriptions are intended only to serve as examples, and that many other embodiments are possible within the scope of the present invention as defined in the appended claims.

Material that exceeds the scope of the claims does not constitute part of the claimed invention.

4. The method of claim 1, wherein distortion operator **H** corresponds to a modulation transfer function describing only a first portion of a distortion generated by the imaging sensor, the method further comprising a post-processing step of deconvoluting a final master image hypothesis to substantially correct a modulation transfer function describing a remainder of a distortion generated by the imaging sensor.

5 The method of claim 1, wherein said correction to the current master image hypothesis includes combining the correction images by deriving a weighted average of values of corresponding pixels in said correction images, the weight of each pixel in each correction image being calculated as a function of a distance as measured in the sampled image between: (i) a point in the sampled image to which the pixel in the correction image is mapped by the transformation operator; and (ii) at least one pixel centroid proximal to said point.

6. The method of claim 5, wherein said function of a distance is derived from distortion operator **H**.

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4. The method of claim 1, wherein distortion operator **H** corresponds to a modulation transfer function describing only a first portion of a distortion generated by the imaging sensor, the method further comprising a post-processing step of deconvoluting a final master image hypothesis to substantially correct a modulation transfer function describing a remainder of a distortion generated by the imaging sensor.

5 The method of claim 1, wherein said correction to the current master image hypothesis includes combining the correction images by deriving a weighted average of values of corresponding pixels in said correction images, the weight of each pixel in each correction image being calculated as a function of a distance as measured in the sampled image between: (i) a point in the sampled image to which the pixel in the correction image is mapped by the transformation operator; and (ii) at least one pixel centroid proximal to said point.

6. The method of claim 5, wherein said function of a distance is derived from distortion operator **H**.

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WHAT IS CLAIMED IS: claims as allowed

1. A method for iterative derivation of a master image from a plurality of sampled images of non-identical, at least partially overlapping, regions of a scene, the master image having an output resolution greater than a maximum resolution of the sampled images, the method comprising:

(a) for each sampled image, defining:

(i) a transformation operator **F** mapping positions within the master image to corresponding positions in the sampled image,

(ii) a distortion operator **H** simulating a distortion associated with an imaging sensor from which the sampled image was generated, and

(iii) a sampling operator **D** for reducing an image from the output resolution to the resolution of the sampled image;

(b) for each sampled image, applying said transformation operator, said distortion operator and said sampling operator to a current master image hypothesis so as to generate a predicted image, and calculating a difference image having pixel values corresponding to the difference in corresponding pixel values between the sampled image and the predicted image;

(c) performing back-projection of each of said difference images to generate a correction image for the current master image hypothesis; and

(d) employing said correction images to perform a correction to the current master image hypothesis to generate a new master image hypothesis,

wherein said back projection includes employing an operator $\mathbf{H}^{bp}$ corresponding to a pseudo-inverse of distortion operator **H**, wherein $\mathbf{H}^{bp}$ approximates to an inverse of **H** at spatial frequencies below a given value and approaches zero at spatial frequencies above said given value.

2. The method of claim 1, wherein $\mathbf{H}^{bp}$ is chosen to substantially satisfy the condition:

$$\mathbf{H}^{bp} \times \mathbf{D}^{t} \times \mathbf{D} \times \mathbf{H} = \mathbf{I}$$

wherein:

I is the unit operator for an image of the output resolution;

D is a sampling operator for reducing an image from the output resolution to the resolution of an input image; and

$\mathbf{D}^{t}$ is an inflation operator for expanding an image from the resolution of the input image to the output resolution.

3. The method of claim 1, wherein distortion operator **H** corresponds to a combination of a modulation transfer function resulting from an optical system of the imaging sensor and a modulation transfer function resulting from a distortion generated by a sensor element array of the imaging sensor.

4. The method of claim 1, wherein distortion operator **H** corresponds to a modulation transfer function describing only a first portion of a distortion generated by the imaging sensor, the method further comprising a post-processing step of deconvoluting a final master image hypothesis to substantially correct a modulation transfer function describing a remainder of a distortion generated by the imaging sensor.

5 The method of claim 1, wherein said correction to the current master image hypothesis includes combining the correction images by deriving a weighted average of values of corresponding pixels in said correction images, the weight of each pixel in each correction image being calculated as a function of a distance as measured in the sampled image between: (i) a point in the sampled image to which the pixel in the correction image is mapped by the transformation operator; and (ii) at least one pixel centroid proximal to said point.

6. The method of claim 5, wherein said function of a distance is derived from distortion operator **H**.

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משרד המשפטים
מסמך זה הינו העתק שנסרק בשלמותו ביום ובשעה המצוינים ,
בסריקה ממוחשבת מהימנה מהמסמך המצוי בתיק,
בהתאם לנוהל הבדיקות במשרד המשפטים.
על החתום

משרד המשפטים (חתימה מוסדית).

Geoda User
14 Jun 2011 01:09:51 +03:00